The Star Switch Controller Used in the Network Control System

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This article describes the Star Switch Controller used in the Network Control System (NCS). The NCS requirements are first discussed as are different design philosophies for multi-computer hardware interface systems. The technique adopted is then presented and the functional characteristics discussed.

I. Network Control System Requirements

The Network Control System (NCS) computer-to-computer or computer-to-device communication requires that any one of a set of 16 computers or devices be able to transfer data to any other of the same set. The data transmission is unidirectional and of short duration to allow similar subsequent transmissions between other sets.

Different system design philosophies for a system to meet these requirements were studied, including a serial as well as parallel bus system and a commutator system (Ref. 1).

The following characteristics led to the selection of the commutator or "star" system:

(1) The often used common bus system involves a great deal of modification and addition of control logic to each device, such as addressing and detection logic and bus priority logic.

(2) The ring interface readily lends itself to message broadcasting, but verification of message acceptance by each of the multiple receivers is difficult.

Broadcasting on a star must be accomplished by means of multiple transmission, and verification of message receipt in the star configuration is simple.

(3) The concept of addressing processes, rather than devices, can be implemented in either configuration with equal effort.

(4) The capability of transmitting variable length blocks, which may be desirable for reducing software overhead is not practical in the ring configuration but is easily accommodated in the star configuration.

(5) A message priority system can be implemented easily in a star configuration. For the ring configuration, an overlay priority system would increase both hardware and software complexity.

(6) Both ring and star configurations have central failure points. The serial nature of a ring causes each interface to be a central point of failure, and location of and recovery from failures appears more complex than in the star since it is difficult for any one processor to pinpoint the failure location. The central point of failure in the star configuration is a single controller and switching bus.

II. The Star Switch Controller Application in the Network Control System

Within the NCS two general classes of messages are transmitted across the Star Switch Controller (SSC). The first is the High-Speed Data Block, which is a 1200-bit data block originated by the DSS and each of the subsystems in the network. The second class of message may be of any length and is generated by any of the subsystems shown at the far right of the diagram in Fig. 1 for transmission to any other of these subsystems.

For added system reliability as well as multiple-path transmission, several star switching networks may well be connected in parallel. For a larger number of ports, any one or several ports may again be connected to other stars in a subcommutation scheme. For priority ranking, one may also consider super commutation schemes where one device is connected to two or more ports of a star.

All messages with the exception of High-Speed Data Blocks sent to and received from the DSN consist of two segments: a preamble which describes the message and the message itself. Transfer of control information is accomplished by transmission of a preamble alone. In addition the Standard Interface and the SSC hardware require two words preceding each transmission which define the operation as a data transfer and specify the destination of the message.

III. Functional Description of the Star Switch Controller

Figure 2 shows an abstract diagram of the SSC. The diagram resembles the face of a clock with two hands M and DM. The face is divided into 16 hours. Hand DM resembles a regular hand, while hand M has the arrowhead at the center pointing inwards rather than toward the periphery.

Hand M scans at high speed in search of a request from any one of 16 input ports to transmit. Once such a request has been located the hand stops. A process code is received by the SSC which is decoded using the process/device assignment table stored in memory. Hand DM is then directed to the assigned device and the requested link is established. Upon completion of data transmission, hand M resumes the scanning and the same procedure is repeated. Hand M rotates in one direction only, while hand DM is instantaneously directed to its destination.

If, during a transmission, the recipient device is unable to receive the data within the allotted time, time-out disconnect occurs. The fact that time-out occurred is reported back to the transmitting device as are other error conditions that may arise.

The SSC contains a routing code table stored in a memory. Any device may load or reload this process/device assignment table, either the entire table, sections thereof, or individual entries.

In the latter case, a device is merely introducing itself, as its present port number is part of the entry. Any device may also read out the entire memory contents for verification.

IV. Functional Components

The major functional components of the SSC, which are shown in block diagram form in Fig. 3, are:

(1) The sequencer, which addresses the input multiplexer and together with it forms a scanning device that scans the request-to-transmit lines.

(2) The inbound multiplexer, which selects the next inbound port with an asserted request-to-transmit line.

(3) The memory, which stores the routing table or process/device code conversion table.

(4) The timing control logic, which is used to receive the routing instruction characters and to load and unload the memory (Refs. 2 and 3).

(5) The demultiplexer, which, when addressed by the output from the code converting memory, selects the outbound port.

The Star Switch Controller is illustrated in Fig. 4 and is described in detail in Specification No. ES508535, Revision A (Ref. 4). This unit is being successfully used in the NCS.

References

1. Thurber, K. J., Jensen, E. D., and Jack, L. A., "A Systematic Approach to the Design of Digital Bussing Structures," Fall Joint Computer Conference, p. 719, 1972.

2. Lee, D. K., *Detail Specifications for Deep Space Network Control System, Standard Interface,* JPL Equipment Specification ES508534, Rev. A, May 1973 (JPL internal document).

3. Anderson, T. O., "NCS Standard Computer Interface Hardware, Its Timing and Timing Control Logic," in *The Deep Space Network Progress Report,* Technical Report 32-1526, Vol. XIX, pp. 152–160, Jet Propulsion Laboratory, Pasadena, Calif., Feb. 15, 1974.

4. Anderson, T. O., *Detail Specification for the Star Switch Controller in the Deep Space Network,* JPL Equipment Specification ES508535, Rev. A, Jan. 1974 (JPL internal document).

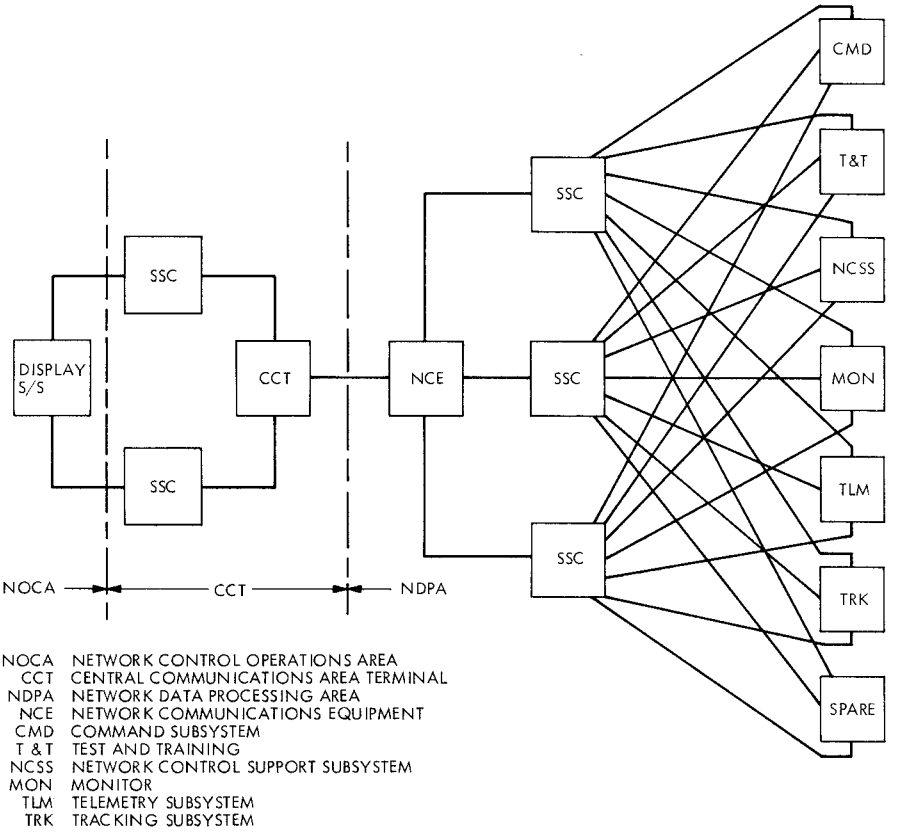

Fig. 1. Application of the SSC in the NCS

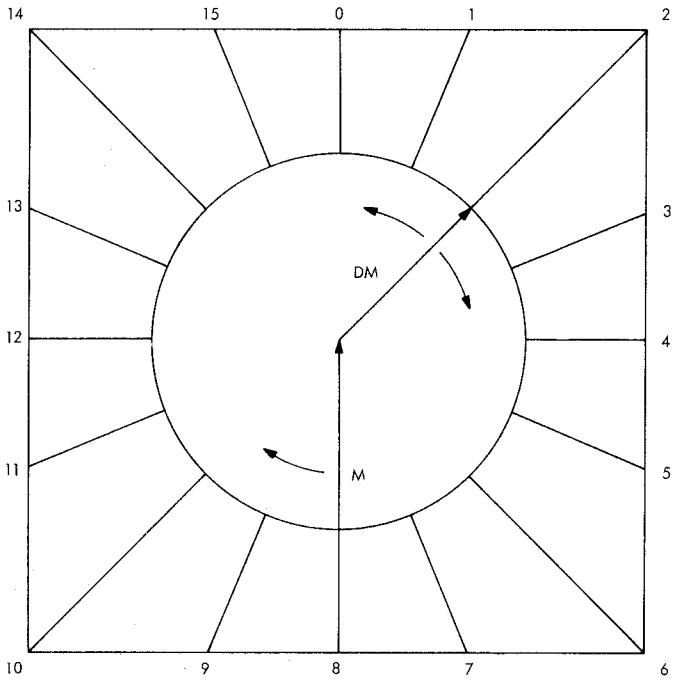

Fig. 2. Abstract diagram of the SSC

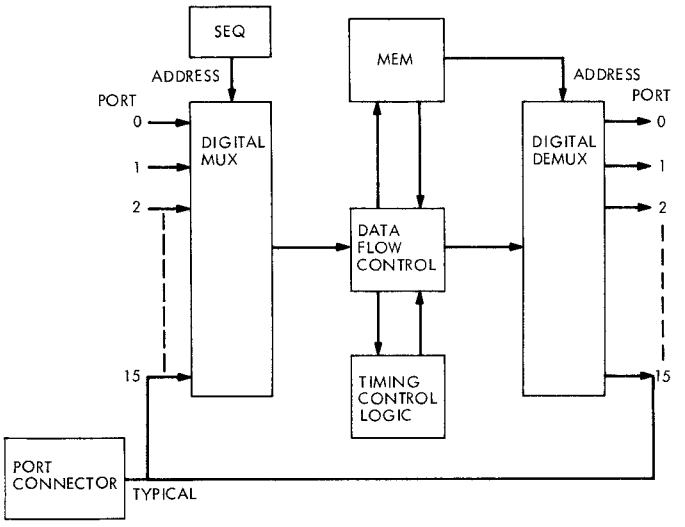

Fig. 3. SSC block diagram

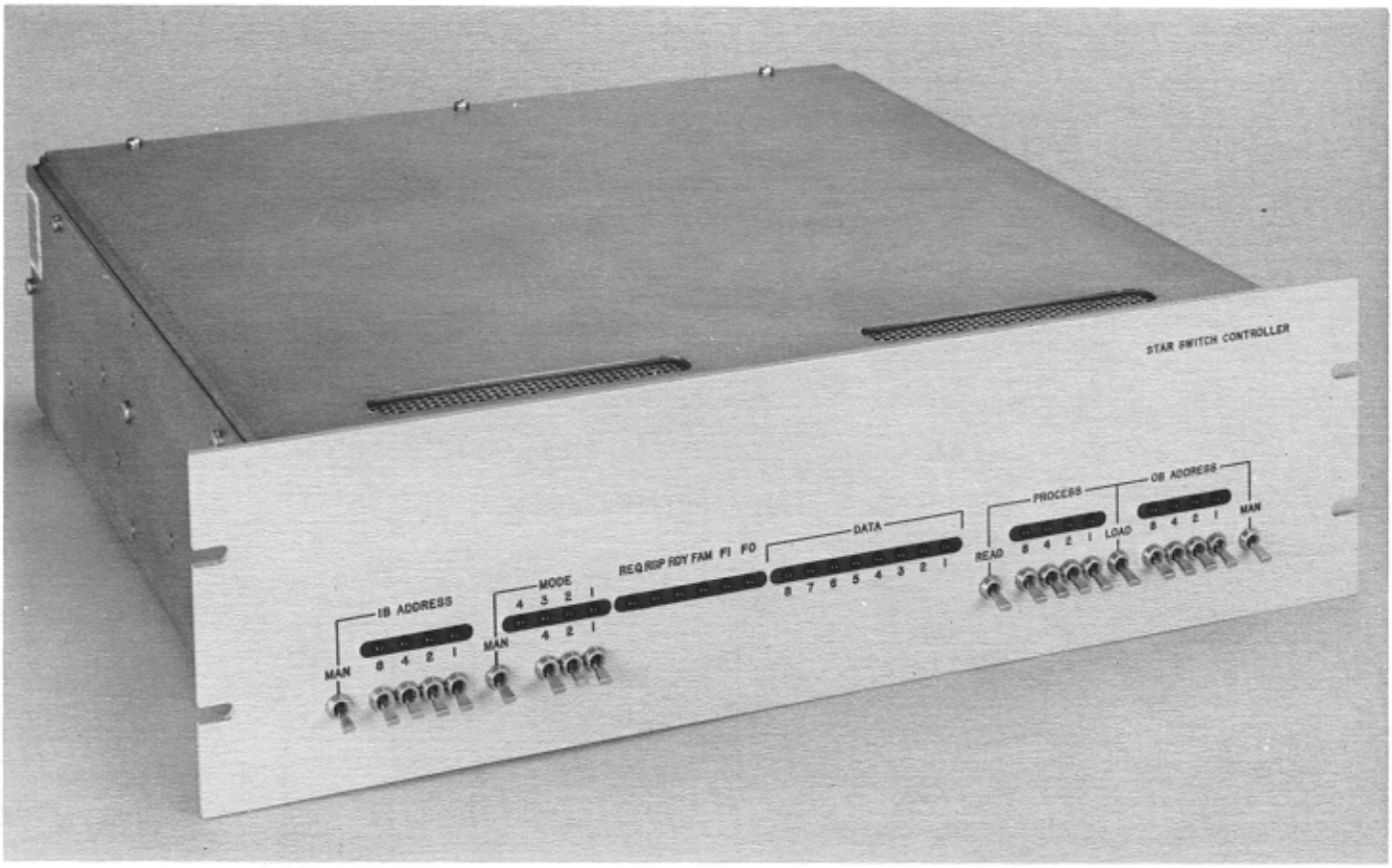

Fig. 4. Star switch controller